(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
10 April 2003 (10.04.2003)

PCT

(10) International Publication Number
WO 03/029646 A1

(51) International Patent Classification[7]: F03B 17/06, 7/00

(21) International Application Number: PCT/DK02/00652

(22) International Filing Date: 2 October 2002 (02.10.2002)

(25) Filing Language: Danish

(26) Publication Language: English

(30) Priority Data:
PA 2001 01440 2 October 2001 (02.10.2001) DK

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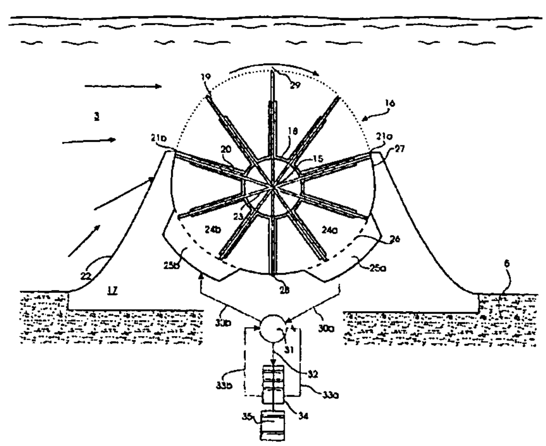
(81) Designated States *(national)*: AE, AG, AL, AM, AT (utility model), AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ (utility model), CZ, DE (utility model), DE, DK (utility model), DK, DM, DZ, EC, EE (utility model), EE, ES, FI (utility model), FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK (utility model), SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: A POWER STATION



(57) Abstract: A power station for utilising the energy in a flow of water (3) flowing mainly horizontally. During operation, the power station is functioning by means of a rotor (2;16) completely or partly submerged and in form of a shaft (6;18) having a number of projecting blades (7;19) and disposed rotatably around a rotation axis mainly transversely to the flow direction. The power station comprises a blade guide (8;20) for each blade extending mainly radially and serving for displaceably accommodating the respective blade (7;19), and means for displacing the blade (7;19) in such a way in its blade guide (8;20) that its peripheral outer edge will describe an enveloping face (12;27) during every rotation of the rotor (2;16) said face having a minimum distance from the rotation axis (1;15) in an intersection line (28) between this face (12;27) and a symmetry plane (29) extending transversely to the direction of flow. Thereby, a simple structure is obtained that is able to optimally utilise the energy in a flow of water. The power station functions effectively in submerged state in a horizontally flowing flow of water (3) whether the flow is coming from one side or the other of the rotor (2;16).

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A power station

The invention relates to a power station for utilising the energy in a mainly horizontally flowing flow of water and functioning during operation by means of at least one rotor submerged completely or partly in the water flow and in form of a shaft having a number of projecting blades and disposed rotatably around a rotation axis mainly transversely to the flow direction.

Due to a globally increasing energy consumption and an increasing environmental awareness, the interest in power stations that can utilise the clean, renewable energy sources is increasing to thereby be able to supplement the energy supplied by power stations utilising the polluting fossil fuels or the unpopular nuclear power.

Hydropower is a clean, renewable energy source, which has been utilised to a great extent now as in the past. Today, the energy in waterfalls, rivers and other streams are especially utilised for generating electric current.

In former times, water wheels having projecting blades have been used to supply mechanical power to machinery in factories or for example for milling flour. These water wheels were mainly placed in streams having a mainly horizontal extent, for example rivers or brooks. However, the energy in such streams is limited and far from covers the great demand for energy of today.

In e.g. sea currents, there are however very large energy resources, which however have been regarded so far as rather difficult to utilise in practice, among other things because the currents often change direction.

An attempt to utilise horizontal water flows is known from the patent document US 4,383,797 which relates to an arrangement having a water wheel operating completely submerged in e.g. a river or channel. The water wheel has radially projecting blades each consisting of an interior, fixed section pivotally connected to an exterior section which is unfolded when the respective blades are rotated in the flow direction, and folded when the blades are rotated in the opposite direction of the flow direction. Thereby, the water wheel is acted upon by a moment that will make the wheel rotate. The known arrangement has a small useful effect and can only be used in one flow direction. In water flows of changing directions, the arrangement is, on the whole, only effective half the time.

The object of the invention is to provide a power station of the kind mentioned in the opening paragraph, that has a simple structure and is able to utilise the energy in a mainly horizontally extending water flow far better than hitherto known.

A second object of the invention is to provide a power station of the kind mentioned in the opening paragraph, which can operate effectively in changing flow directions.

A third object of the invention is to provide a power station of the kind mentioned in the opening paragraph, which can operate effectively in submerged state in a horizontally extending water flow.

A fourth object of the invention is to provide a power station of the kind mentioned in the opening paragraph and having a rotor which is arranged to form part of a hydraulic gear for a power station of the kind mentioned in the opening paragraph.

A fifth object of the invention is to provide a valve for, in dependence of the flow direction, automatically unidirect the

water flow to a turbine forming a second part of a hydraulic gear for a power station of the kind mentioned in the opening paragraph.

The novel and unique features according to the invention, whereby this is achieved, is the fact that the power station comprises a blade guide, for each blade, extending mainly radially and serving for accommodating the respective blade, and means for displacing the blade in such a way in the blade guide that its peripheral outer edge will describe an enveloping face during each of the rotations of the rotor, said enveloping face having a minimum distance from the rotation axis in an intersection line between this face and a symmetry plane extending transversely of the flow direction.

In a symmetric area around the minimum distance of the enveloping face from the rotation axis, the blades are drawn more or less into the respective blade guides. They are therefore not or only to a smaller extent affected by the water flow during operation. The blades in the opposite area of the enveloping face are however pushed more or less out of their respective blade guides. These blades are therefore affected effectively by the water flow, the result of which is that they are brought along in the flow direction and thereby will bring the rotor into rotation, whatever side of the rotor the flow direction is coming from. In this way, the energy in the water flow is utilised effectively. It can furthermore be seen that the rotor can operate effectively when it is completely submerged in the water flow.

In a first embodiment of the power station according to the invention, the means for displacing the blades can consist of a pneumatic installation having pneumatic cylinders for giving the blades the desired displacement back and forth in their blade guides. The pneumatic installation is arranged in such a

way that the blades are made to follow the enveloping face whatever side of the rotor the flow is coming.

Alternatively, the means for displacing the blades can consist of a hydraulic installation having hydraulic cylinders for giving the blades the desired displacement back and forth in their blade guides. The hydraulic installation is also arranged in such a way that the blades are made to follow the enveloping face whatever side of the rotor the flow is coming.

However, it is to be noted that the enveloping face in this case can have one shape when the water flow is coming from one side of the rotor and another shape when the water flow is coming from the other side. The two enveloping faces can e.g. be symmetrically formed around the symmetry plane.

In a second embodiment of the power station according to the invention, the means for displacing the blades can be of a purely mechanical kind. In this case, a circumferential guide is arranged at each end of the rotor, said guide being congruent with a cross section through the enveloping face. The blades can furthermore be provided with e.g. slide shoes or pins having rollers mounted rotatably for following the path of the circumferential guide during the rotation of the rotor. This embodiment is especially simple and reliable.

Alternatively, the circumferential guide can be following the enveloping face crosswise and completely or partly lengthwise, whereas the outer edges of the blades or rollers on these blades are running along the guide thus formed during the rotation of the rotor.

The forces from the water flow affect the extended blades with a considerable bending moment which has to be absorbed by the respective blade guides which thereby are subjected to a very heavy load at the same time as the blades also must be able to

be displaced in their blade guides without a tendency to edging and getting stuck during this.

With a view to overcome this problem, the rotor can be designed with oppositely paired blades, which can be interconnected by strong bars. Thereby, both blade guides absorb the bending moment simultaneously, and as the two guides furthermore are located at a relatively great distance from each other, the load on the guides is reduced considerably.

In one embodiment, the rotor shaft can have a relatively large diameter. In this case, the blade guide can be extending radially in towards the rotation axis from the periphery of the shaft which furthermore is coinciding with the enveloping face in a symmetry area around the intersection line between the symmetry plane and the enveloping face, whereas the opposite section of the enveloping face is extending at a distance from the periphery of the shaft. During operation, the retracted blades in said symmetry area will be inoperative, whereas the extended blades in the opposite section of the enveloping face will catch the water flow and thereby make the rotor rotate.

In an alternative second embodiment, the rotor shaft can have a relatively small diameter and have blade guides extending radially out from the periphery of the shaft. A symmetry area around the intersection line between the symmetry plane and the enveloping face can then be covered by a shield for guiding the water flow round the rotor in this area so that it will only be the blades in the opposite rotor area that actively can utilise the energy in the water flow and thereby make the rotor rotate.

The shield can advantageously contact or nearly contact the intersection line and from this line have an increasing

distance to the enveloping face with the largest distance at the longitudinal edges of the shield.

As can be seen, the shield and the rotor are defining, on either side of the intersection line, a pump chamber having a volume which is reduced gradually in the direction from the longitudinal edge of the shield to the intersection line. During the rotation of the rotor, the blades will therefore try to build up a positive pressure in the - seen in the direction of rotation - first chamber and a negative pressure in the second chamber.

When the two chambers are connected to a water conduit, the water will therefore flow from the first - to the second chamber in an internal water flow. This characteristic feature of the power station according to the invention can advantageously be used for utilising the energy in the internal water flow in a turbine, which is inserted in said water conduit.

During operation, one side of the rotor is, in other words, functioning as a water motor driven by the energy in the external water flow, whereas the other side of the rotor, that is the shield side, is functioning as a pump driven by the water motor and pumping an internal water flow through a turbine which typically is connected to an electric generator. Thereby, the energy recovered from the external water flow is converted into electric current.

Instead of the turbine, a valve can be inserted in the water conduit, which valve is connected to the turbine and arranged to ensure that the internal water flow through the turbine will always flow in the same direction even if the external water flow periodically changes direction. The turbine can therefore function optimally irrespective of the direction of the flow.

Under the influence of the external water flow, the rotor of the power station will rotate at a relatively low rate, whereas an electric generator necessarily has to rotate at a relatively high rate to effectively be able to generate the desired electric current from the energy recovered from the water flow at en economically reasonable price. It is therefore necessary for the slow rotation of the rotor to be geared up to the fast rotation of the generator.

Evidently, this can take place by means of a conventional mechanical gear, which however would be disproportionately large and costly due to the high gearing that is required. A mechanical gear, which is submerged in a water area, will furthermore be difficult to inspect and service.

However, the above described arrangement in which the rotor automatically converts the energy from the external water flow to energy in an internal water flow which drives a turbine constitutes in itself a hydraulic gear which easily can be arranged to gear the very slow rotation of the rotor up to the very fast rotation of the electric generator.

If the conditions at site permit, the turbine and electric generator can conveniently be disposed in a station on land. If so desired, one single turbine can serve several rotors located in several favourable positions in the water area.

The rotor arrangement can advantageously be located on or near the bottom of a water area where there is a suitably strong undercurrent. If the rotor arrangement is disposed in this way, it will not obstruct the maritime traffic, and it will furthermore not risk being hit and damaged by e.g. driftwood. The rotor can advantageously be horizontally oriented.

Alternatively, a number of rotor arrangements can be disposed in a line extending out from a coast or an area off a coast

where there is a sufficiently strong current following the coast line at least in the main.

The rotors can be horizontally or vertically oriented. In the former case, the shields can advantageously face upwards. The line of rotor arrangement will form a near-shore, permanent source for clean energy and at the same time advantageously function as an effective coastal protection.

The rotors can furthermore be protected by a mesh or lattice for preventing humans, animals or fish entering between the blades.

The invention will be explained in greater details below, describing only exemplary embodiments with reference to the drawing, in which

Fig. 1 is an end view of a first embodiment of a power station according to the invention,

Fig. 2 is a side elevational view of the power station in fig. 1,

Fig. 3 is a sectional view of a second embodiment of a power station according to the invention,

Fig. 4 is a perspective view of the power station in fig. 3,

Fig. 5 is an axial sectional view of a valve for the embodiment of the power station according to the invention in figs. 3 and 4,

Fig. 6 is a sectional view taken along the line VI-VI of fig. 5,

Fig. 7 is a sectional view taken along the line of VII-VII of fig. 5,

Fig. 8 is a sectional view taken along the line of VIII-VIII of fig. 5, and

Fig. 9 is a plan view of a power station consisting of four vertically disposed rotors located in a line extending out from a coast.

Figs. 1 and 2 show a first embodiment of a power station having a rotor 2 oriented horizontally about a rotation axis 1 and submerged in a horizontally extending water flow 3 and extending transversely of this water flow. The rotor is rotatably journaled in a base 4 located on the seafloor 5.

The rotor is constructed of a shaft 6 having a total of 18 projecting blades 7. Each of these blades is displaceably mounted in a radially extending blade guide 8 extending in towards the rotation axis 1 from the periphery 9 of the shaft.

The base 4 is extending in a curve - seen in cross section - up from the seafloor 5 to the rotor from each side of this rotor and thereby forms guide faces 10 for guiding the water flow into the rotor.

Baffles 11 at each end of the rotor are furthermore extending obliquely in towards the rotor and together with the baffles 10 serve for increasing the volume of the water flow, which drives the rotor during operation, whereby the energy production of the power station at the same time is increased.

During rotation, the peripheral outer edges of the rotor blades 7 are describing, as shown in fig. 1, an enveloping face 12 which coincides with or follows the periphery 9 of the shaft 6 at a short distance in a first area at the base 4, the

blades here being completely or almost completely retracted into the shaft. In a second area where the blades are pushed more or less out of their respective blade guides, the enveloping face is extending at a distance from the periphery of the shaft 6.

Thereby, the enveloping face 12 will obtain the shape in fig. 1 if the flow is coming from the left, seen in the figure. If the flow is coming from the right, a second enveloping face is formed which is symmetrical around the first one around a symmetry plane extending crosswise to the flow and includes the rotor shaft 1.

In the first area of the enveloping face, the blades are not or at least only to a smaller degree affected by the water flow, whereas they, in the second area, are positively affected by a force which will make the rotor rotate in the direction indicated by the arrow.

The blades can in themselves be displaced back and forth in their respective blade guides in any expedient way. The important thing is that their outer edges will follow the desired enveloping face during rotation, that is the enveloping face that will ensure that the power station will operate with optimum utilisation of the energy content of the water flow.

In an advantageous embodiment, the blades are however displaced by means of a pneumatic or hydraulic installation (not shown) with one pneumatic or hydraulic cylinder for each blade (not shown) for displacing the blade back and forth in its respective blade guide.

The energy recovered from the water flow by the rotor during operation will typically be converted into electric current by means of a generator (not shown) connected to a gearing (not

shown) which again is connected to the rotor shaft 6 by means of a output shaft 14.

Gearing and generator are protected against the harsh surroundings under the water in a watertight casing 13 (fig. 2) from which an electric cable (not shown) leads from the generator up on to e.g. land.

During normal circumstances, the rotor is rotating relatively slowly under the influence of the flowing water which can be flowing at a rate of e.g. between 10 and 100 m/min., whereby the rotational speed of a rotor having an active diameter of 5 m will be no more than 0.5 - 5 rpm, whereas a generator typically has to rotate at e.g. 1000 - 3000 rpm. Therefore, a high gearing is required between the rotor and the generator. The gearing can e.g. be established by means of a conventional mechanical or hydraulic gear.

Figs. 3 and 4 show a second embodiment of a power station having a rotor 16 oriented horizontally about a rotation axis 15, submerged in a horizontally extending water flow 3 and extending crosswise of this flow. The rotor is rotatably journaled in a base 17 located on the seafloor 5.

The rotor is constructed of a shaft 18 having a total of 10 projecting blades 19, each displaceably mounted in a radially extending blade guide 20 extending radially out from the shaft 18.

The base 17 is extending in a curve - seen in cross section - up from the seafloor 5 to the rotor from each side of this rotor and thereby forms guide faces 10 for guiding the water flow into the rotor and a shield around the lower part of the rotor.

During operation, the water flow is affecting each of the extended blades with a force that creates a considerable moment, which will load the blade and associate blade guide 20 heavily. As seen best in fig. 3, two of each pair of diametrically opposed blades 19 are therefore interconnected by means of strong bars 23 to distribute the moment on two blade guides which advantageously are located at a distance from each other so that a long moment arm is obtained and correspondingly reduced loads on the blade concerned and its blade guide.

As shown in fig. 3, first - and second pump chambers 24a,b are designed under the rotor in the base 17, said chambers are communicating with first - and second transit chambers 25a,b via a perforated wall 26. The perforated wall serves for preventing e.g. fish, which possibly have entered the rotor, from entering the respective transit chamber. Instead, they are taken back to the water flow around the rotor during the continued rotation of the rotor.

The radial outer edges of the blades 19 are describing an enveloping face 27 which, in this case, is extending symmetrically about a symmetry plane 29 extending crosswise to the water flow and is including the axis 15 of the rotor.

In an area formed symmetrically around the intersection line 28 between the symmetry plane 29 and the enveloping face 27, the rotor is covered by the base 17 which thereby functions as a shield which will guide the water flow out of said symmetry area so that the blades in this area will be at least substantially inactive.

In the opposite area of the rotor 16 where the blades 19 are pushed more or less out of their blade guides 20, the blades are, on the contrary, active. During the influence of the pressure from the flowing water, the blades in this area will

therefore make the rotor rotate in the direction indicated by the arrow. Therefore, the rotor is functioning as a motor in this area, which utilises the energy in the water flow as propellant.

In the area covered by the base 17, the very same rotor is, on the contrary, functioning as a pump which advantageously is creating a positive pressure in the pump chamber 24a and a negative pressure in the pump chamber 24b when the rotor is rotating in the direction indicated by the arrow and vice versa when the rotor is rotating in the opposite direction.

If the transit chambers 25a,b are allowed to communicate with the surrounding water flow via the space between two successive blades that are located at an adjacent longitudinal edge 21a,b on the base, it will not, as desired, be possible to create a positive or negative pressure in the pump chamber.

Therefore, the rotor 16 is designed in such a way that the distance between the outer edges of these blades 19 are smaller than or equal to the distance between the respective transit chamber 25a,b and the corresponding longitudinal edge 21a,b on the shield.

In order to simultaneously avoid that the desired pressure difference between the two transit chambers is compensated via the space between two successive blades in the area between the two transit chambers, the rotor is furthermore designed in such a way that the spacing between the outer edges on two adjacent blades which are at or in the area between the two transit chambers is smaller than or equal to the spacing between the transit chambers.

In this area, the side of the base facing the rotor is extending along a circular arc, seen in cross section, in order to thereby avoid the blades at the transition from one

to the other transit chamber will perform a pumping operation to the detriment of the creation of a negative pressure in the, seen in the direction of rotation, second pump chamber.

Each transit chamber can have the same length as the associate pump chamber. But in practice, the transit chambers need only have a relatively small extent in the longitudinal direction of the rotor as the water can freely communicate with the transit chambers via the space between the blade guides.

Via water conduits 30a,b, the transit chambers 25a,b are connected to a valve 31 which will be described in detail below. Via other water conduits 32 and 33a,b, the valve is furthermore connected to a turbine 34 connected to an electric generator 35.

When the power station is operating in a water flow flowing in the direction indicated by the arrow, the rotor will be rotating clockwise, seen in the figure, whereby an internal water flow from the pump chamber 24a through the transit chamber 25a, the water conduit 30a, the valve 31, the water conduit 32, the turbine 33, the water conduit 33b, the water conduit 30b, the transit chamber 25b to the pump chamber 25b is created due to the pressure difference between the two pump chambers 24a and 24b. During this, the water conduit 33a is closed.

Thus, the rotor is functioning partly as a motor driven by the energy of the water flow, partly as a pump driven by the motor and sending an internal water flow through the turbine 34. Thereby, the slow rotational speed of the rotor in the turbine is converted into the high rotational speed required by the generator 35, whereby the need for a large, costly mechanical gear which furthermore is difficult to inspect and service when submerged in water is eliminated.

As the turbine is connected to the rotor via said water conduits, it can, if so desired, freely be disposed at a distance from the rotor together with the generator, for example on land.

In the embodiment in fig. 4, the blades 19 are pushed back and forth in their respective blade guides by means of rollers 36 rotatably mounted on the blades and running in a circumferential guide 37 at each their end of the rotor during the rotation of the rotor. The two guides 37 are congruent with the desired enveloping face 27 so that the peripheral outer edges of the blades automatically will follow this face when the rotor is rotating. As the blades 19 are connected in pairs to the bars 23, there is only one roller for each pair of blades.

Figs. 5, 6, 7 and 8 show the valve 31 in fig. 3 in detail, which valve is operating with a plug 38 in a valve body 39 provided with, as shown, connections for the water conduits 30a,b and 33a,b.

The plug consists of a casing 40 closed at one end by a bottom 41 and divided into two halves by a partition 42.

The plug can be rotated 180° by a revolving damper 43 in a, seen in the figure, upper chamber 44 arranged in an upper section of the valve body 39. The revolving damper 43 is furthermore fixed on a shaft 45 journaled in a bearing 46 in the valve body 39 and furthermore fixedly connected to the plug 38.

A partition 47 is extending between the journal 46 and the inside of said upper section in the valve body 39 and is dividing, together with the revolving damper 43, the upper chamber into two variable sections 48a and 48b communicating

with underlying sections 50a and 50b in the valve body 39 via holes 49a and 49b.

The water conduit 32 is connected to the valve body via first and second branches, 51a and 51b respectively. In the lower bottom of the plug, there is an aperture 52 communicating with the branch 51a when the plug is in the position shown, and with the branch 51b when the plug is rotated 180° in relation hereto.

In the casing 40 of the plug, an aperture 53 is furthermore made which is communicating with the water conduit 30a when the plug is in the position shown, and upper and lower apertures 54 and 55 communicating at the same time with the water conduits 30b and 33b respectively.

When the rotor is rotating in the direction indicated by the arrow in fig. 3, the plug will be in the position shown in figs. 5 - 8. The internal water flow furnished by the valve 31 from the first pump chamber 24a of the rotor via the water conduit 30a, will then pass the plug 38 of the valve via the apertures 53 and 52 and then return to the valve 31 via the branch 51a, the water conduit 32, the turbine 34, and the water conduit 33b. Subsequently, the internal water flow will again pass the plug of the valve but this time via the apertures 55 and 54 to finally be conveyed to the second pump chamber 24b of the rotor via the water conduit 30b.

During this, the turbine 34 is driven by the pressure difference between the two pump chambers, a positive pressure existing in the first pump chamber and a negative pressure in the second as mentioned above.

The positive pressure is conveyed via the aperture 49a to the first variable section 48a of the upper chamber 44, whereas the negative pressure is conveyed to the second variable

section 48b via the aperture 49b. Thereby, the pressure difference has been able to rotate the revolving damper 43 from a first stop 56a to a second stop 56b and thereby the plug 38 to the position shown.

When the flow changes and the rotor therefore is rotating in the opposite direction of the one in fig. 3, a positive pressure will be created in the second pump chamber 24b and a negative pressure in the first pump chamber 24b and thereby positive pressure in the second variable section 48b of the upper chamber 44 and negative pressure in the second variable section 48b of the chamber. The pressure difference between the two chambers will rotate the revolving damper 43 until it is stopped by the first stop 56a, and the damper 43 will thus have rotated the plug 180°.

The internal water flow is now flowing from the second to the first pump chamber, the aperture 52 in the lower bottom of the plug having at the same time been rotated over the second branch 51b of the water conduit 32 so that the internal water flow always passes the turbine in the same direction whether the external water flow is flowing in one or the other direction. And as can be seen, the valve will automatically set itself according to the flow direction.

Fig. 9 shows a power station consisting of four vertically placed rotors 57 located in a row extending out from a coast 58 crosswise to the water flow 59 which, in the figure, is flowing from right to left but which can be flowing from left to right in other cases. The four rotors are mounted on a joint base 60.

In this case, the turbine 27 and the generator 28 are housed in a housing 61 on land, the turbine being fed the internal water flow via the water conduits 62.

In this embodiment, the power station is at the same time functioning as an effective coastal protection.

The invention is described above and shown in the drawing on the assumption that it is the upper part of the horizontally oriented rotor that is active, whereas the lower part is inactive.

However within the scope of the invention, it can just as well be the other way round, that is so that the upper part of the rotor is inactive and the lower part is active.

According to the conditions in the flow area in question, a more or less fine meshed lattice (not shown) can furthermore be mounted for protecting the rotor against being hit by e.g. driftwood, and fish, animals and humans from being hit by the rotor.

Patent claims

1. A power station for utilising the energy in a mainly horizontally flowing flow of water (3) and functioning during operation by means of at least one rotor (2;16) submerged completely or partly in the flow of water (3) and in form of a shaft (6;18) having a number of projecting blades (7;19) and disposed around a rotation axis (1;15) mainly transversely to the flow direction, and a mainly radially extending blade guide (8;20) for each blade (7;19) serving for displaceably for accommodating the respective blade (7;19), **characterised** in that the power station comprises
   - means for displacing the blade (7;19) in such a way in its blade guide (8;20) that its peripheral outer edge will describe an enveloping face (12;27) during each of the rotations of the rotor, said enveloping face having a greater distance from the rotation axis in the areas in which the blade (7;19) is affected by the pressure from the flow of water than in the areas in which this is not the case.

2. A power station according to claim 1, **characterised** in that the means for displacing the blade (7;19) are pneumatic or hydraulic.

3. A power station for utilising the energy in a mainly horizontally flowing flow of water (3) and functioning during operation by means of at least one rotor (2;16) submerged completely or partly in the flow of water (3) and in form of a shaft (6;18) having a number of projecting blades (7;19) and disposed around a rotation axis (1;15) mainly transversely to the flow direction, wherein the power station comprises

- a mainly radially extending blade guide (8;20) for each blade (7;19) serving for displaceably accommodating the respective blade (7;19),
- means for displacing the blade (7;19) in such a way in its blade guide (8;20) that its peripheral outer edge will describe an enveloping face (12;27) during each of the rotations of the rotor (2;16), said enveloping face having a minimum distance from the rotation axis (1;15) in an intersection line (28) between this face and a symmetry plane (29) extending transversely of the direction of flow and including the rotation axis (1;15), **characterised** in
- that the rotor (2;16) and the shield define a pump chamber (24a,b) on either side of the intersection line (28),
- that a transit chamber (25a,b) is designed opposite each pump chamber (24a,b) and is communicating with the respective pump chamber (24a,b) via at least one aperture between the two chambers,
- that the spacing between each transit chamber (25a,b) and the adjacent longitudinal edge (21a,b) on the shield is equal to or greater than the spacing between the outer edges of two adjacent blades (7;19) located at this longitudinal edge (21a,b),
- that the spacing between the two transit chambers (25a,b) is equal to or greater than the spacing between the outer edges on two adjacent blades (7;19) located at or in the area between the two chambers (25a,b), and
- the shield in said area is extending along a circular arc, seen in cross section.

4. A power station according to claim 1, **characterised** in that the means for displacing each blade (7) in its blade guide (8) comprise a pneumatic installation having pneumatic cylinders for making the peripheral outer edges

of the blades (7) describe said enveloping face (12) during each of the rotations of the rotor (2).

5. A power station according to claim 1, **characterised** in that the means for displacing the blades (19) in the blade guides (20) consist of at least one circumferential guide (37) which is congruent with a cross section through the enveloping face (27), and at least one following device (36) on at least half the blades (7) for following the path of the at least one circumferential guide (37) during the rotation of the rotor (16), and that each following device (36) consists of an axially extending slide or of journal having a rotatably mounted roller.

6. A power station according to claim 1 or 2, **characterised** in that the blade guides (8) are extending radially inwards from the periphery (9) of the shaft, and that the enveloping face (12) is at least mainly coinciding with the periphery (9) of the shaft along an area extending symmetrically on both sides of the intersection line (28), whereas the rest of the enveloping face (12) is extending at a distance from the periphery (9) of the shaft.

7. A power station according to claim 3 or 4, **characterised** in that the blade guides (20) are extending radially outwards from the periphery of the shaft, that there is a shield which is following the enveloping face (27) at a relatively short or no distance lengthwise and crosswise and is defined by a longitudinal edge (21a,b) on either side of the intersection line (28), and that the two longitudinal edges (21a,b) is located at mainly the same distance from the intersection line (28).

8. A power station according to any of the claims 1 - 6, **characterised** in that the blade guides (8;20) are located in pairs diametrically opposite each other, that the blades (7;19) in two opposite blade guides (8;20) are interconnected by at least one bar (23).

9. A power station according to claims 1 - 7, **characterised** in that the two transit chambers (25a,b) are interconnected to a hydraulic circuit in which a turbine (34) and a valve (31) are inserted, the valve being arranged to control the water flow flowing through the circuit during operation in such a way that this water flow will pass the turbine in one and the same direction even if this water flow (3), into which the rotor (2;16) is submerged, changes direction.

10. A power station for utilising the energy in a mainly horizontally flowing flow of water (3) and functioning during operation by means of at least one rotor (2;16) submerged completely or partly in the flow of water (3) and in form of a shaft (6;18) having a number of projecting blades (7;19) and disposed around a rotation axis (1;15) mainly transversely to the flow direction, the blades being displaceably mounted in a blade guide (8;20) for each blade (7;19) on the shaft (6;18), **characterised** in that the power station comprises

- a shield covering the rotor (2;16) within an area defined by two longitudinal edges (21a,b) on the shield,
- two successive pump chambers (24a,b) defined by the shield and the rotor (2;16),
- a transit chamber (25a,b) designed opposite each pump chamber (24a,b) and communicating with the respective pump chamber (24a,b) via at least one aperture between the two chambers,

- a spacing arranged between each transit chamber (25a,b) and the adjacent longitudinal edge (21a,b) on the shield and being equal to or greater than the spacing between the outer edges on two adjacent blades (7;19) located at this longitudinal edge (21a,b),
- a spacing arranged between the two transit chambers (25a,b) and being equal to or greater than the spacing between the outer edges on two adjacent blades (7;19) located at or in the area between the two chambers (25a,b),
- a shield section extending between the two transit chambers (25a,b) and along a circular arc, seen in cross section,
- a hydraulic circuit connecting the two transit chambers (25a,b), and
- a turbine (34) inserted in the hydraulic circuit.

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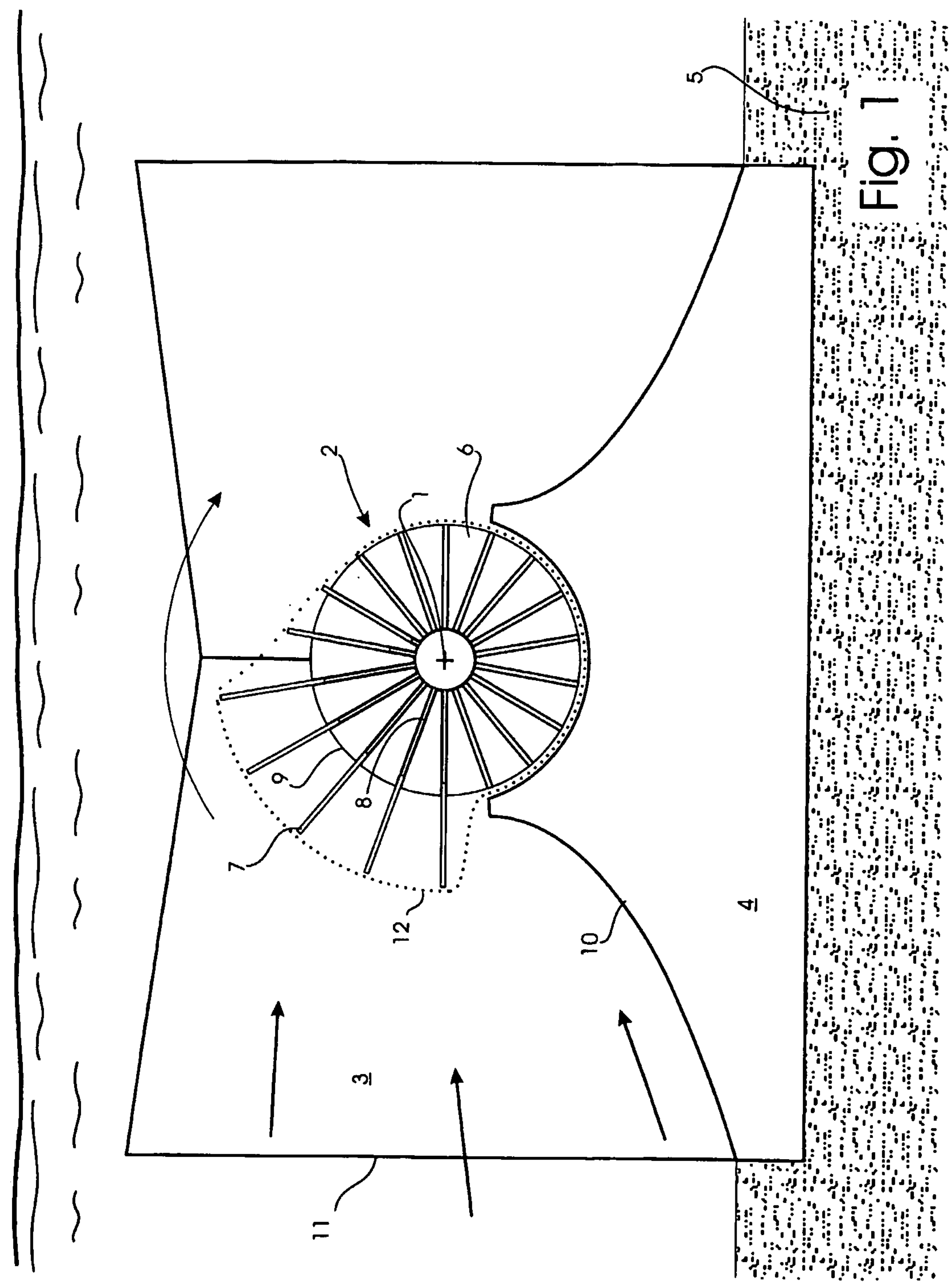

Fig. 1

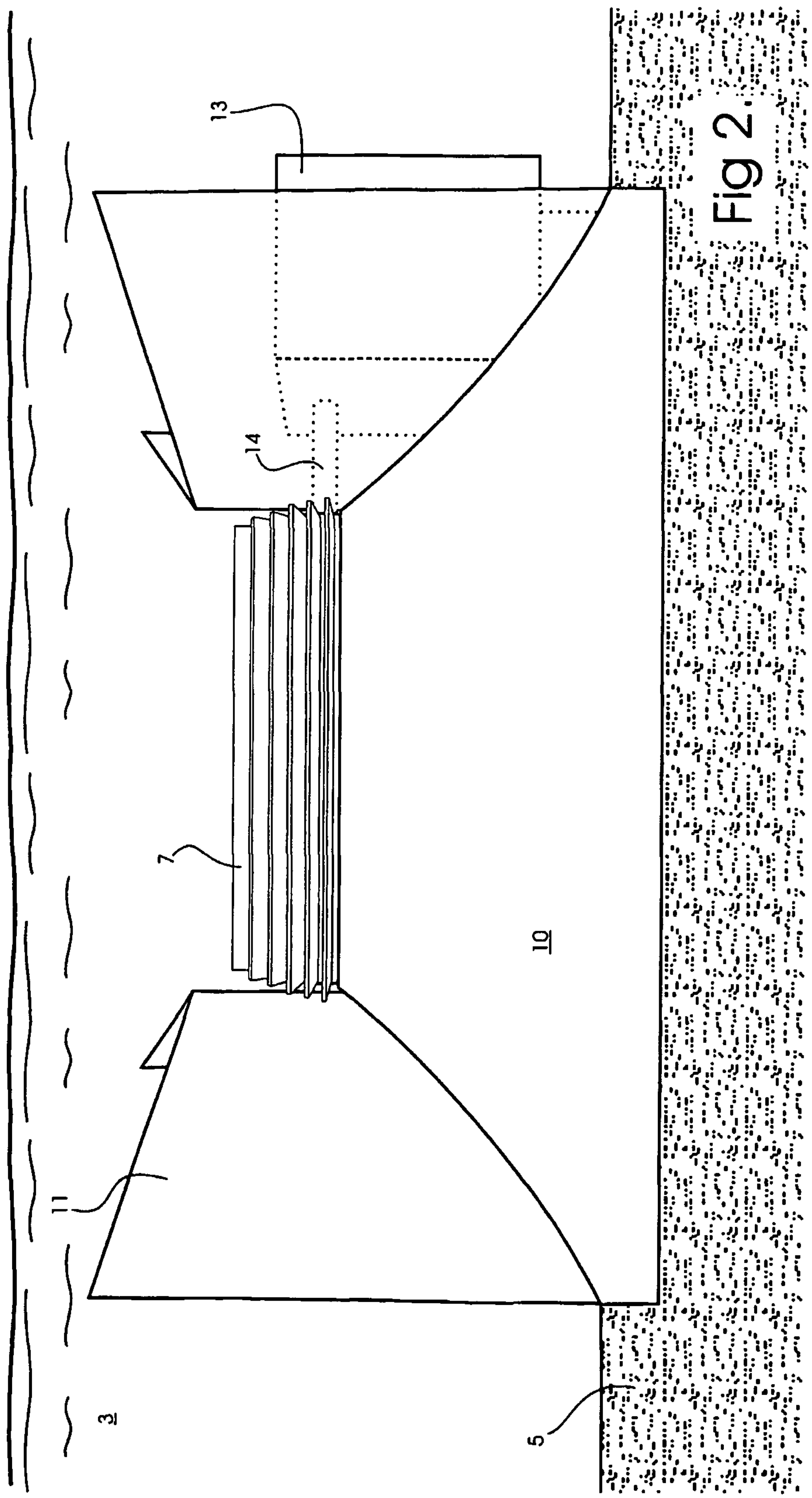

Fig 2.

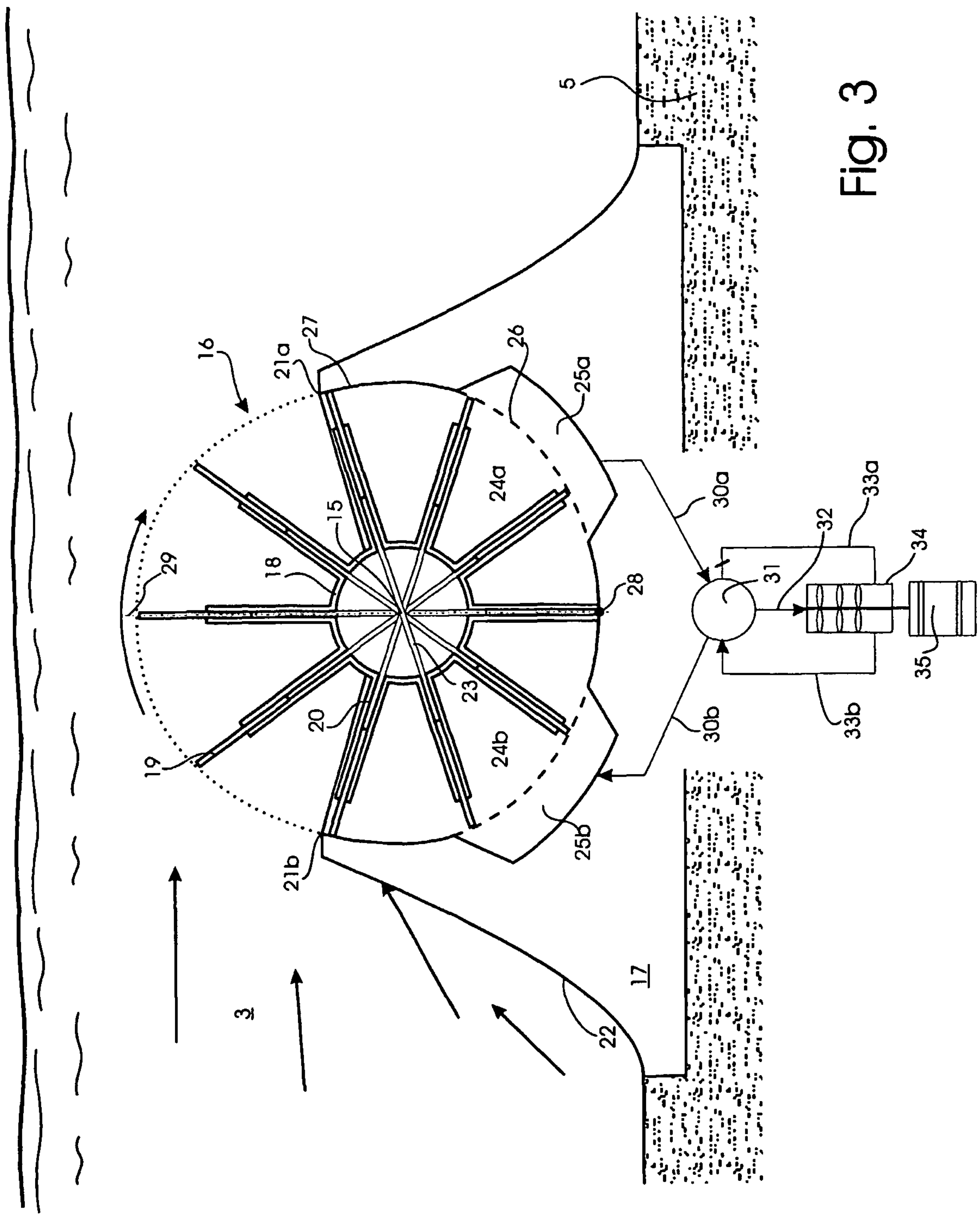
5
16
21a
27
26
25a
24a
30a
33a
32
34
31
15
18
29
28
23
20
24b
30b
33b
35
19
21b
25b
17
3
22

Fig. 3

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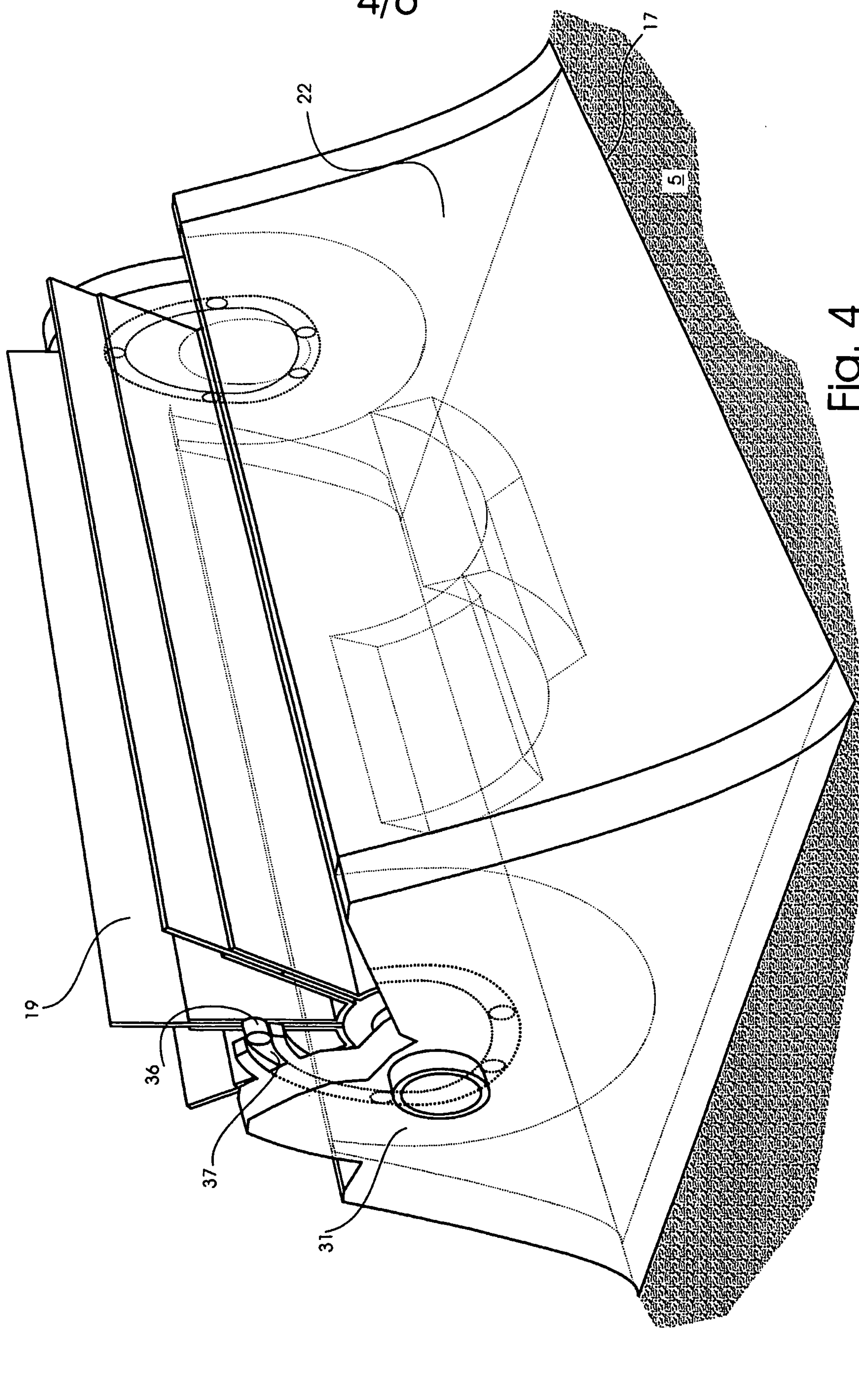

Fig. 4

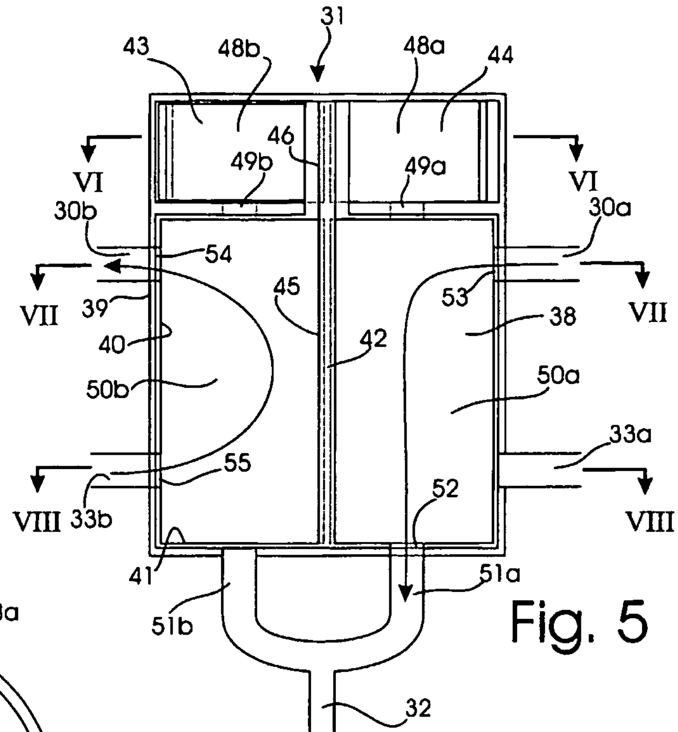

Fig. 5

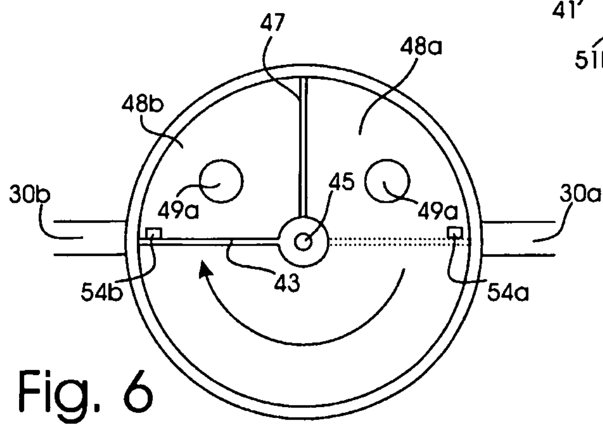

Fig. 6

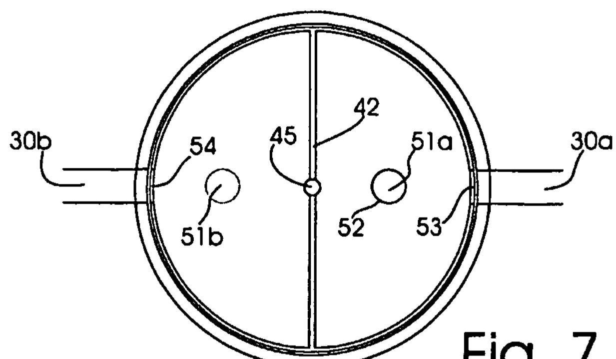

Fig. 7

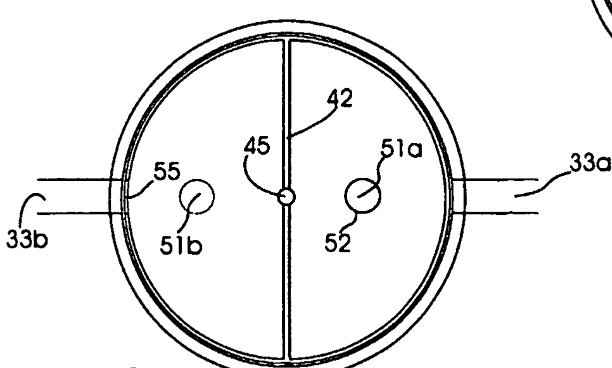

Fig. 8

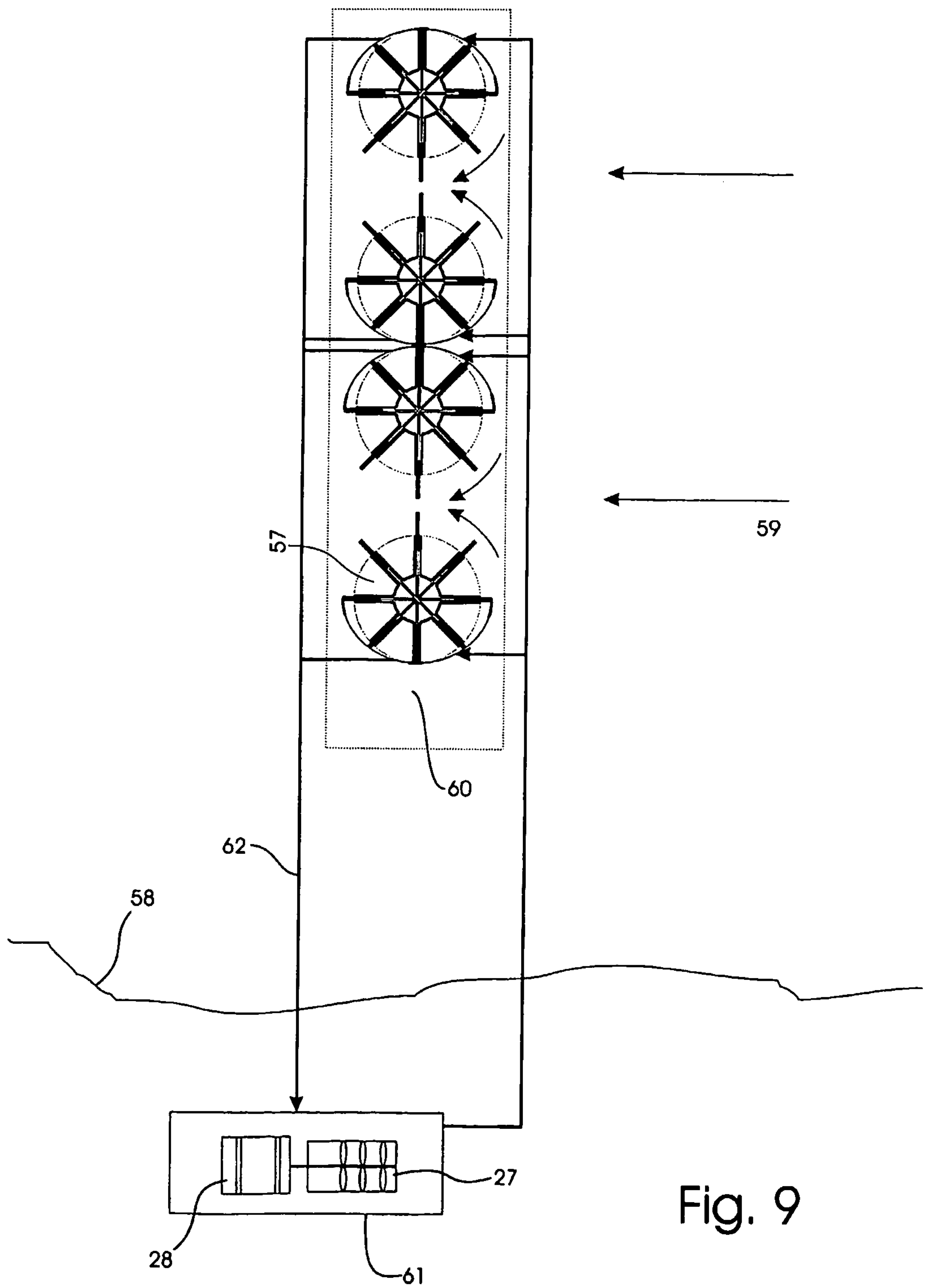

Fig. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK 02/00652

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: F03B 17/06, F03B 7/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: F03B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A		2-4,7-10
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X	GB 2205615 A (SAIFORD UNIVERSITY CIVIL ENGINEERING LIMITED), 14 December 1988 (14.12.88)	1,5,6
A		2-4,7-10
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A	US 4382797 A (E.M. LEE), 17 May 1983 (17.05.83)	1-10
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☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 January 2003	10-01-2003
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Per-Olof Warnbo / JA A Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/DK 02/00652

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